

# CHARACTERIZING LAND SURFACE CHANGE AND LEVEE STABILITY IN THE SACRAMENTO-SAN JOAQUIN DELTA USING UAVSAR RADAR IMAGERY

*Cathleen Jones<sup>1</sup>, Gerald Bawden<sup>2</sup>, Steven Devere<sup>3</sup>, Joel Dudas<sup>4</sup>, Scott Hensley<sup>1</sup>*

<sup>1</sup> Jet Propulsion Laboratory, California Institute of Technology

<sup>2</sup> California Water Science Center, USGS

<sup>3</sup> Hydrofocus, Inc., Davis, CA

<sup>4</sup> Delta-Suisun Marsh Office, California Dept. of Water Resources

Email: cathleen.jones@jpl.nasa.gov

## 1. INTRODUCTION

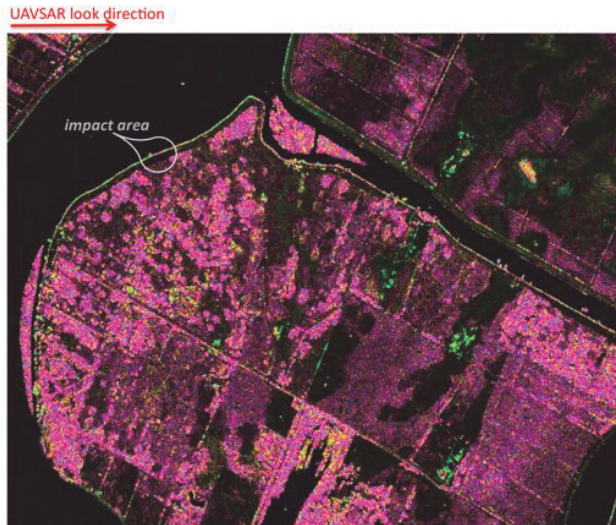
The Sacramento-San Joaquin Delta is one of the primary water sources for the state of California and represents a complex geographical area comprised of tidal marshland, levee rimmed islands that are used primarily for agriculture, and urban encroachment. Land subsidence has dropped many of the Delta islands 3 to >7 meters below mean sea level and requires nearly 1700 km of levees to maintain the integrity of the islands and flow of water through the Delta. The current average subsidence rates for each island varies, with 1.23 cm/yr on Sherman Island and 2.2 cm/yr for Bacon Island, as determined by ground-based instruments located at isolated points in the Delta [1]. The Delta's status as the most critical water resource for the state, an endangered ecosystem, and an area continuously threatened with levee breakage from hydrostatic pressure and the danger of earthquakes on several major faults in the San Francisco area make it a focus of monitoring efforts by both the state and national government. This activity is now almost entirely done by ground-based efforts, but the benefits of using remote sensing for wide scale spatial coverage and frequent temporal coverage is obvious.

The UAVSAR airborne polarimetric and differential interferometric L-band synthetic aperture radar system [2] has been used to collect monthly images of the Sacramento-San Joaquin Delta and much of the adjacent Suisun Marsh since July 2009 to characterize levee stability, image spatially varied subsidence, and assess how well the UAVSAR performs in an area with widespread agriculture production.

## 2. POLSAR AND DifInSAR RESULTS

Preliminary multi-look polarimetric imagery and interferograms with 7-m pixel postings show excellent coherence across the region with less than anticipated decorrelation in area of active agriculture production. The monthly flights provide detailed time series information about changes in the vegetation radar reflective properties that are likely associated with biomass changes. The imagery also shows soil moisture variability between neighboring fields, as are seen in Figure 1, which is an interferogram of an area in the eastern Delta made from HH-polarimetric data collected approximately 7 weeks apart. The figure also shows that the levees surrounding each island are clearly resolved in the UAVSAR imagery, which enables monitoring of the levees for small-scale deformation that could be precursors of failure. Figure 2 is an example of this usage that shows a levee on Bradford Island deformed by ship impact.

We find that POLSAR and DifInSAR imagery can give complementary information about surface change, as seen in Figure 3, which shows a POLSAR image of the Suisun Marsh area on the left and a differential interferogram of the same area on the right. Changes are clearly seen in the interferogram in some areas where the polarimetric imagery indicates potential classification differences, possibly pointing to differential phase changes due to different scattering mechanisms and surface composition characteristics rather than surface deformation. Several example areas of this type are circled in Figure 3. We are exploring in more detail the potential of combining POLSAR and DifInSAR results to identify changes due to subsidence/uplift from biomass



**Fig. 2.** Combined correlation map and differential interferogram showing section of the north Bradford Island levee that was deformed by ship impact in August 2009.

or soil moisture variations, all of which can introduce interferometric phase changes and mask extraction of a single desired property from DifInSAR data.

### 3. ACKNOWLEDGMENT

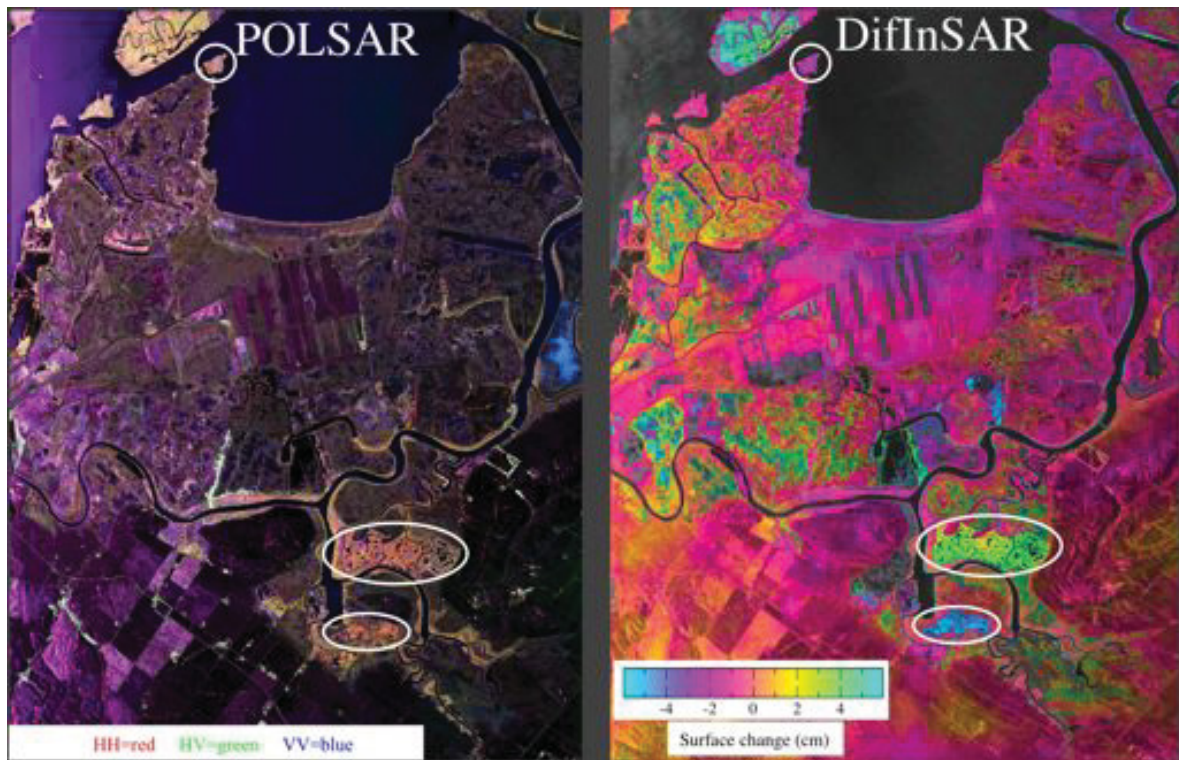
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### 4. REFERENCES

- [1] S. Deverel and D. Leighton. Historic, Recent, and Future Subsidence, Sacramento-San Joaquin Delta, California, USA. *San Francisco Estuary and Watershed Science*, 8(2), 2010.
- [2] S. Hensley, H. Zebker, C. Jones, T. Michel, R. Muellerschoen, and B. Chapman. First deformation results using the NASA/JPL UAVSAR instrument. *Proceedings of the 2nd Asian-Pacific Conference on Synthetic Aperture Radar, 26-30 Oct., Xian, Shanxi*, pp. 1051-1055, 2009.



**Fig. 1.** Differential interferogram of an area in the eastern part of the Sacramento-San Joaquin Delta formed from images collected on 17-June-2009 and 8-Aug-2009. The interferogram shows sensitivity to soil moisture changes as is evidenced by the phase changes along field boundaries.



**Fig. 3.** Polarimetric imagery (left) and differential interferogram (right) of an area in the Suisun Marsh. Circles indicate examples of several areas where changes in the interferogram correspond to locations with different polarimetric signatures from the surrounding area.